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EVALUATION OF THE BACKGROUND IONIZING RADIATION AND HEALTH STATUS OF PERSONNEL IN LABORATORIES AT SOME TERTIARY INSTITUTIONS IN DELTA STATE.

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ABSTRACT

Exposure to ionizing radiation even at low doses may be harmful to cells. In this study, an in-situ measurement of Background Ionization Radiation (BIR) exposure rate in laboratories Tertiary Institutions in Delta State, Nigeria was carried outusing a Geiger Muller counter (GMC 320$^+$). The purpose is to estimate the BIR health parameter and hence predict the radiation health status of personnel in these laboratories. For all the measurements readings were taken three consecutive times at a height of one metre above the ground for each point. A geographical positioning system (GPS) was used to determine the coordinates of the study areas. The results indicate that the mean values of the exposure rates range from 0.05 – 0.17 μSv/hr for indoor and 0.08 – 0.14 μSv/hr for outdoor. The obtained annual effective dose equivalent (AEDE) values for the selected institutions range from 0.63 – 1.02 mSv/yr for the indoor and 0.15 – 0.24 mSv/yr for outdoor. These values are within the recommended safety limit of 1.0 mSv/yr by the International Commission on Radiation Protection. The calculated mean excess lifetime cancer risk (ELCR) for the institutions range from 1.72 x 10^{-3} – 2.77 x 10^{-3} for the indoor environment. These values are higher than the 0.29 x 10^{-3} value recommended by United Nations Scientific Committee on the Effects of Atomic Radiation. This implies the laboratory personnel in these institutions are likely to develop cancer at the age of 55 years and above. There is the need for regular monitoring by the relevant body.

Keywords: Indoor/Outdoor Radiation, Annual Effective Dose Equivalent and Excess Lifetime Cancer Risk.

INTRODUCTION

Man by its daily activities is exposed to radiation in various forms and intensities ranging from background radiation to that of other man made sources. Laboratory experiences are known to enhance students' understanding of specific scientific facts and concepts and the development of scientific reasoning (America's Laboratory Report, 2006). They also encourage students to develop interest in learning science or the appropriate discipline and scientific reasoning. Furthermore, they ensure that students have sufficient training in resourcefulness and manual skills. Laboratories are therefore vital learning resources.

These laboratories which can be that for physics, applied physics, chemistry, applied chemistry, medical and life sciences, earth sciences and languages are mostly indoor environments in the form of buildings. Indoor environments are known to be associated with fairly high level of background radiation relative to their immediate outdoor environments. This situation is attributable to radioactive radon gas (Rn^{22}) build up (Mokobia, 2004) as well as the building materials (Mokobia, et al 2003). This gas usually seeps into the indoor dwelling through the ground.

This odourless, tasteless and colourless gas decays within a short time (3.8 days), producing more radioactive daughters (Figure 1) and has been identified to be significant in internal dosimetry (Mokobia, 2004). The radiation emitted during its alpha decay could cause not only damage to the Deoxyribonucleic acid (DNA) but also cause cancer of the lungs (Mokobia, 2010).

Furthermore, in some of these laboratories some low level radioactive materials are used. These provide some sort of external radiation exposure sources. For example radioactive chemicals (uranium and thorium compounds) in chemical laboratories (Janžekovič and Križman, 2007) and some low activity gamma and alpha radiation sources in the physical science laboratories. There might be leakage arising from improper storage of these radioactive sources as required by the International Atomic Energy Agency (IAEA, 1990). This could result in increased background radiation level and consequently increased exposure of the appropriate personnel. This increased exposure to low-levels of radiation is known to be associated with increased cancer risk over a lifetime (USEPA, 2018). The literature appears to be scarce on the safety of laboratory personnel in Delta State. The closest is the work by Agaja (2012) who appraised the safety climate in government and private analytical laboratories in Warri, Delta State, Nigeriaand was not focused on radiation safety.

This work then sought to fill this gap by examining the BIR health status of personnel working in some laboratories located in some tertiary institutions in Delta State. Specifically, the work measured the BIR exposure in these laboratories and estimated their consequent health parameters. The radiological health status of the personnel was predicted.

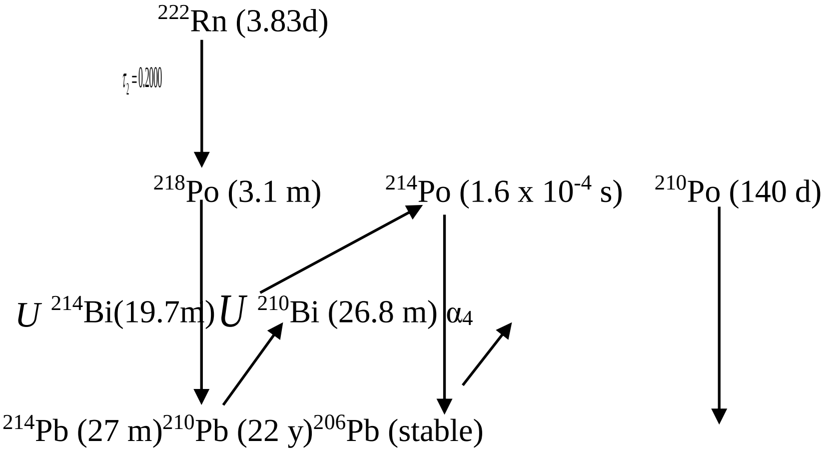

Figure 1: Decay of ^{22}Rn (adapted from Mokobia et al, 2004)

↓ : α-decay, ↗: β-decay

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MATERIALS AND METHODS

The BIR exposure levels in laboratories in selected tertiary institutions in Delta State were measured using a Geiger Müller counter (GMC 320^{+}). The selection was occasioned by the acceptability of the appropriate authorities. Some details of the various laboratories in each of these institutions are given in Table 1 while the geographical map showing their locations is presented in Figure 2. During each of the measurements the counter was placed on a stand one meter above the ground in accordance with standard principle (Abadat et al, 2014). The choice height of this is due to the fact that the highly radiosensitive human gonad is approximately this distance above the ground. At each measurement position three readings were taken and the mean noted. The geographical coordinates of each location was taken with the use of the Geographical Positioning System(GPS). These procedures were carried for both the indoor and outdoor measurements. In each measurement, it was ensured that the counter was not blocked by any structure.

The radiation health parameters arising from the measured dose rates, that is the annual effective dose equivalent (AEDE) and the excess life-time cancer risk (ELCR) were calculated using appropriate equations (UNSCEAR, 2000). For the calculation of the indoor (IAEDE) and outdoor (OAEDE) health parameters, the occupancy factor 0.8 and 0.2 were respectively employed with the understanding that these caliber of workers (laboratory personnel) spend most of their time inside the main laboratories or the enclosed offices. Excess lifetime cancer risk (ELCR) was calculated using the World Health Organization (WHO) currently recommended lifetime expectancy of 55 years for Nigeria, (WHO, 2018) and the cancer risk factor (RF) per Sievert of 0.05 stochastically determined for the members of the public (Oyeyemi et al, 2017).

The obtained values were statistically analyzed using statistics of the mean and graphs. Comparisons of these obtained values were made in addition to comparison with the international recommended values. Also the radiation health of the personnel in the studied laboratories was predicted. The relationship between latitude and BIR exposure rates was also predicted using an appropriate graph. A radiocontour map of the dose rate distribution was drawn.

Table 1: Name, location of the institution and type of laboratory

Name	Location	Codes	Coordinates	Elevation(m)	Laboratory types
Delta State University	Abraka	ELSU	5.809°N 6.122°E	25	AEB, ANT, CHM, GEO, MBC, PHM,PHC, PHY
Federal University of Petroleum	Effurun	UPRE	5.573°N 5.836°E	42	PET. ENGR, PHY
Micheal and Cecillia Ibru University	Agbarha – Otor	CIU	5.533°N 6.059°E	41	BIO, CHM, PHY
Novena University	Ogume - Kwale	NUNI	5.751°N 6.208°E	47	BIO, CHM, PHY
Western Delta University	Oghara	WDU	5.941°N 5.674°E	39	BCH, CHM, MCH, GEO/PHY
Delta State Polytechnic	Ogwashi – Uku	DSPOG	6.214°N 6.561°E	231	BIO, CHM, PHY
Delta State Polytechnic	Ozoro	DSPOZ	5.556°N 6.241°E	42	BIO, CHM, MCH, PHY
College of Education	Agbor	COEAG	6.262°N 6.1803°E	157	BIO, CHM, PHY
College of Education	osogar	COEMOS	5.907°N 5.739°E	37	BIO, CHM, PHY
College of Education	Warri	COEWA	5.538°N 5.737°E	30	BIO, CHM, PHY

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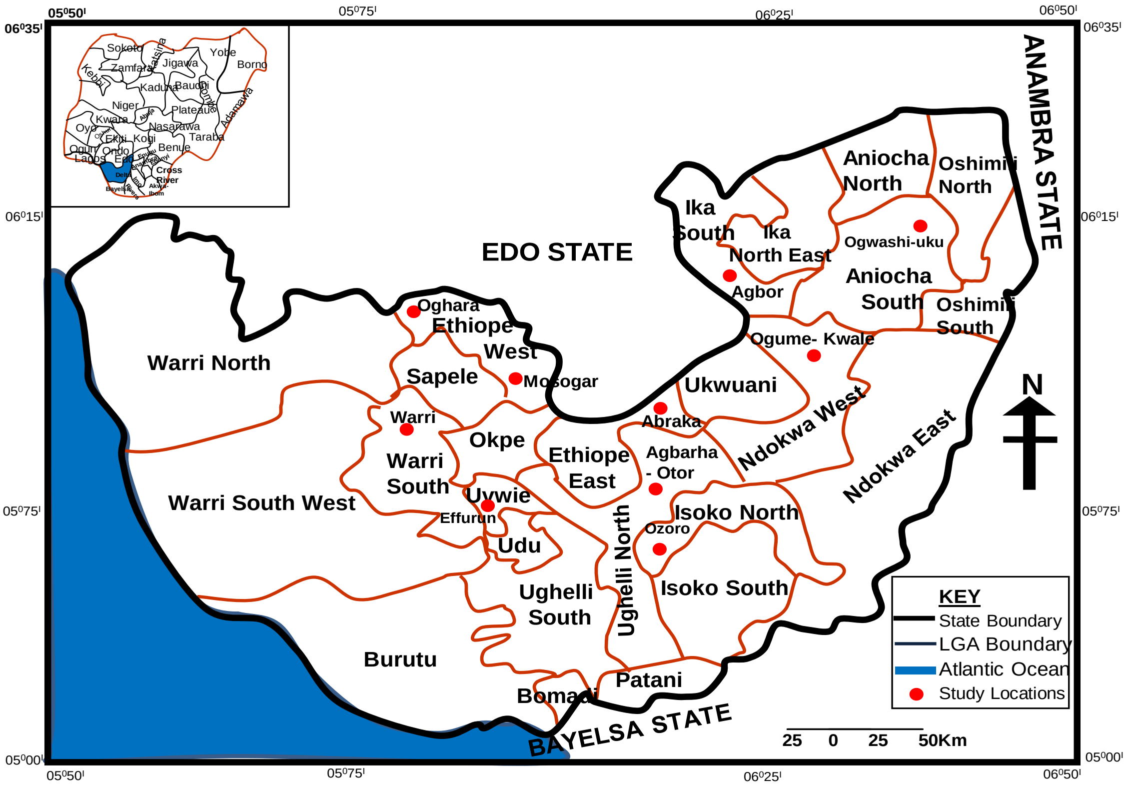

Fig. 2 : Map of Delta State showing study locations
Ministry of Lands, Survey and Urban Development, (MLSUD) Asaba (2002).

RESULTS

The mean vales of the BIR exposure rates are presented in Table 2, while the values of the calculated health parameters are presented in Table3.

Table 2: Mean values for measured BIR levels in the selected institutions in Delta State

Institutions	Coordinates	Elevation (m)	Mean Dose Equivalent values (μSv/hr)	
			Indoor	Outdoor
DELSU	5.809°N 6.122°E	25	0.10	0.09
FUPRE	5.573°N 5.836°E	42	0.15	0.14
MCIU	5.533°N 6.059°E	41	0.14	0.11
NUNI	5.751°N 6.208°E	47	0.1	0.10
WDU	5.941°N 5.674°E	39	0.10	0.09
DSPOG	6.214°N 6.561°E	231	0.10	0.09
DSPOZ	5.556°N 6.241°E	42	0.10	0.11
COEAG	6.262°N 6.1803°E	157	0.09	0.09
COEMOS	5.907°N 5.739°E	37	0.10	0.09
COEWA	5.538°N 5.737°E	30	0.11	0.11
AVERAGE			**0.11 ± 0.02**	**0.10 ± 0.02**

Table 3: Estimated mean values of the health parameters

Institutions	IAEDE (mSv/yr)	ELCR (x 10^{-3})	OAEDE (mSv/yr)	ELCR (x 10^{-3})
DELSU	0.68	1.84	0.16	0.42
FUPRE	1.02	2.77	0.24	0.65
MCIU	0.96	2.61	0.19	0.53
NUNI	0.70	1.91	0.17	0.46
WDU	0.67	1.82	0.20	0.56
DSPOG	0.72	1.97	0.15	0.41
DSPOZ	0.72	1.96	0.19	0.47
COEAG	0.63	1.72	0.16	0.43
COEMOS	0.68	1.85	0.16	0.43
COEWA	0.79	2.16	0.19	0.51
MEAN	**0.76**	**2.06**	**0.18**	**0.49**
STD	**0.13**	**0.35**	**0.03**	**0.07**

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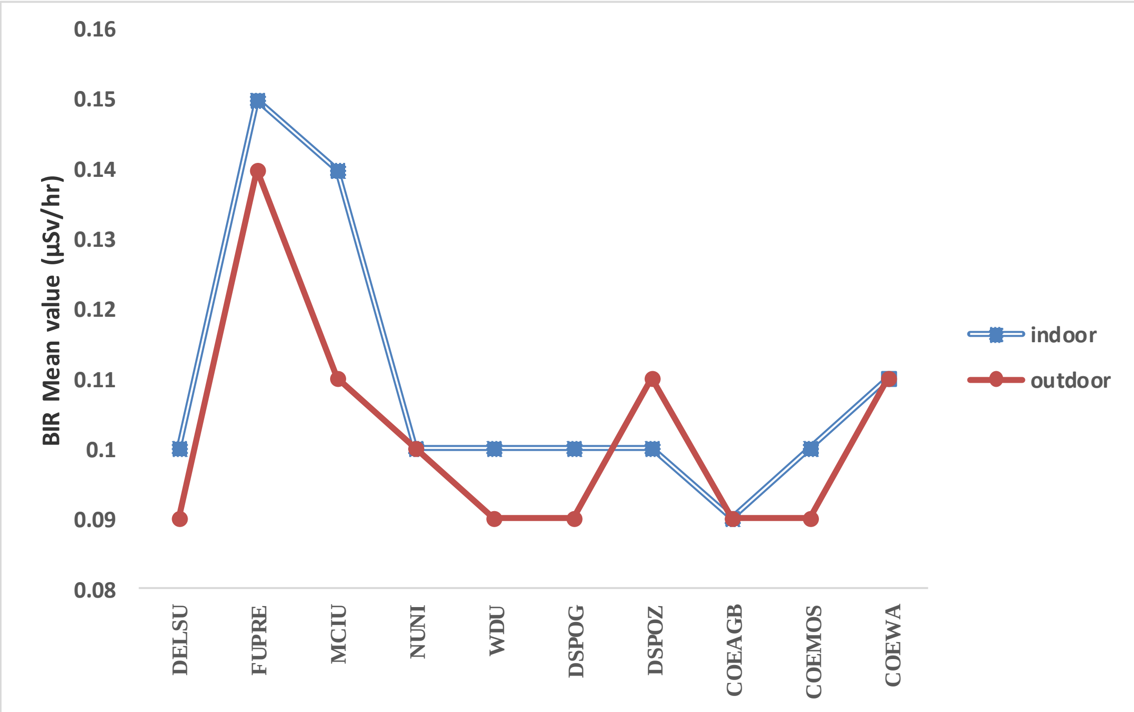

Figure 3: Comparison of mean BIR levels in the laboratories in different institutions

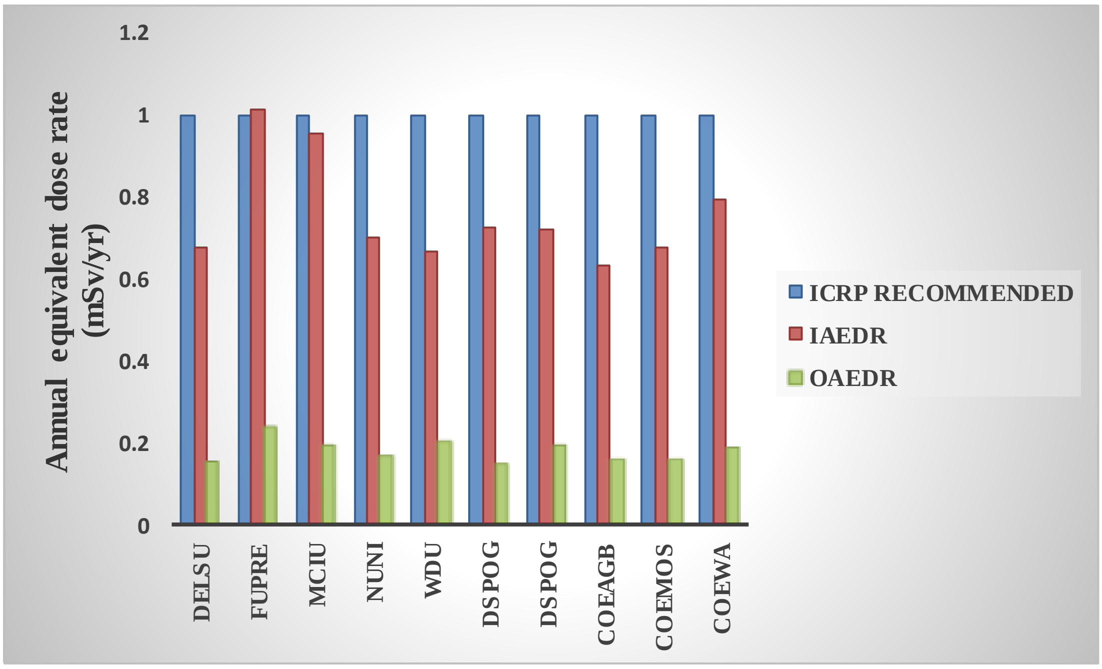

Figure 4: Comparison of annual equivalent dose rate in tertiary institutions with ICRP (2007) recommended value

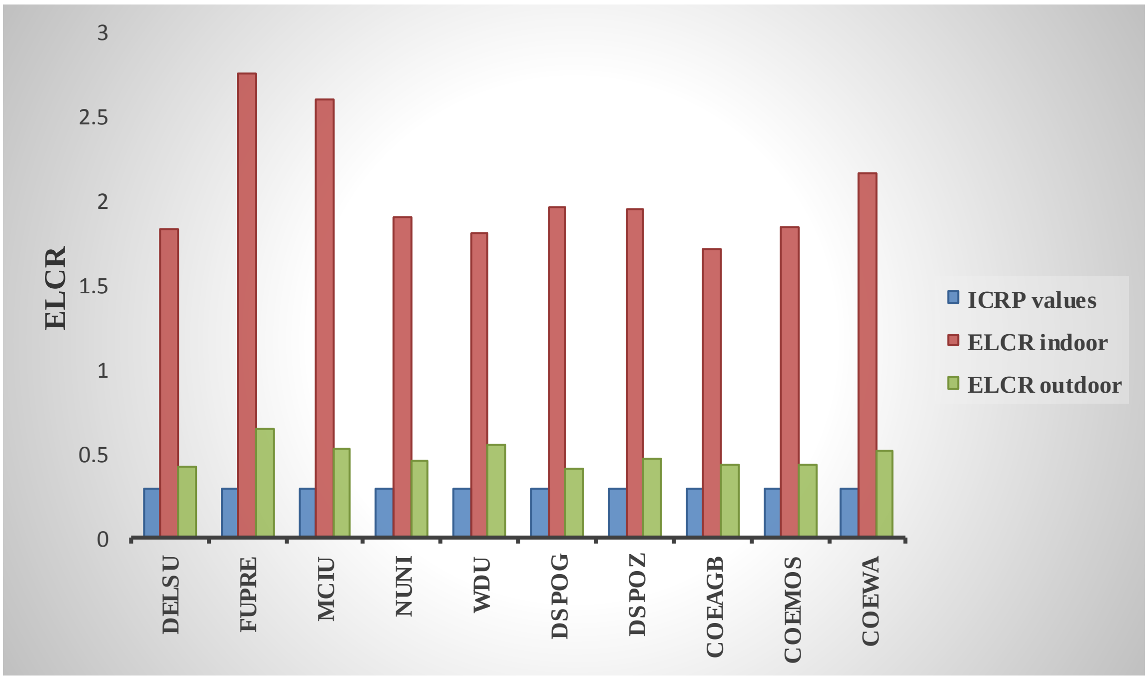

Figure 5: Comparison of ELCR in tertiary institutions with ICRP (2007) recommended

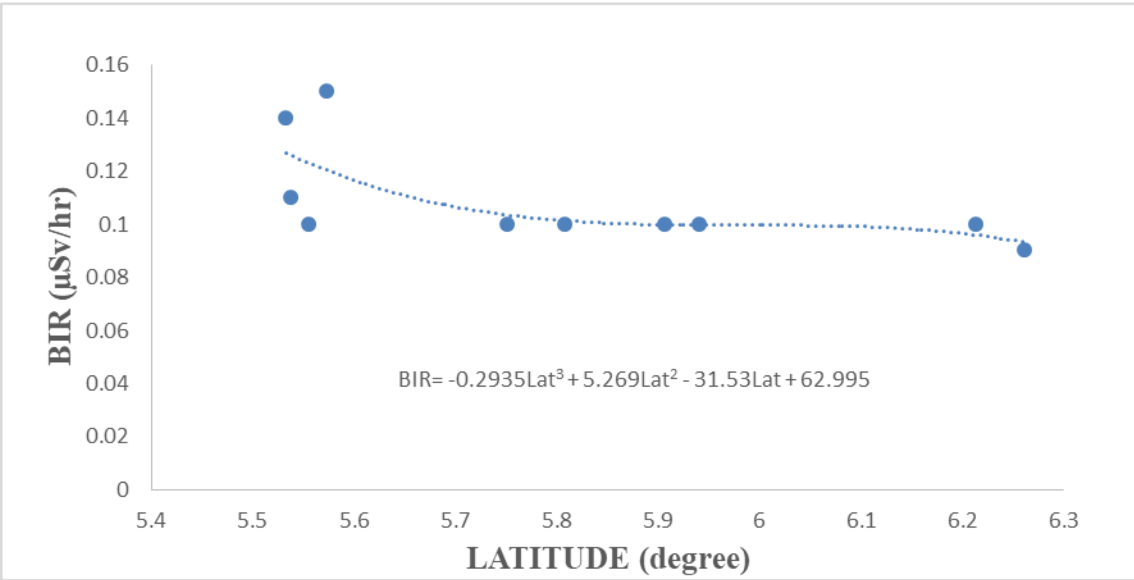

Figure: 6 Comparing the BIR Values with Latitudes

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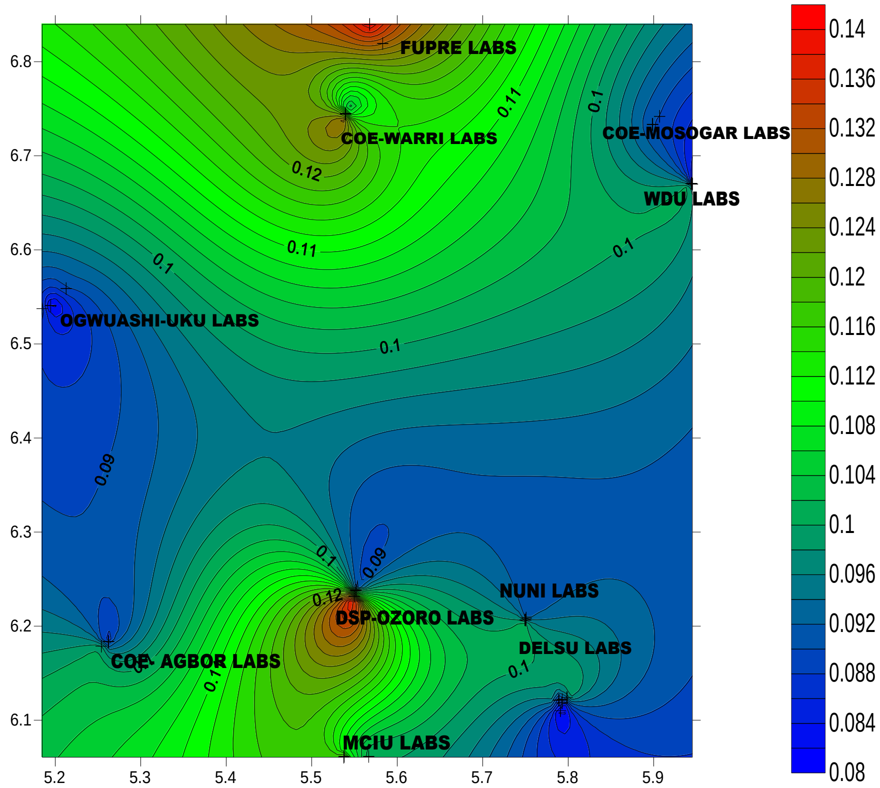

Figure 7: 2D contour map of BIR for various locations

DISCUSSION

The mean values of the dose equivalent obtained in the institutions as shown in Table 2 range from (0.09 - 0.15) μSv/hr indoor with a mean of 0.11 ± 0.02 μSv/hr. The corresponding outdoor range is 0.09 – 0.14 μSv/hr, with a mean of 0.10 ± 0.01 μSv/hr. The maximum values of both the indoor and outdoor measurements (0.15 μSv/hr and 0.14 μSv/hr) were observed in FUPRE. This may be as a result of radon build up due to inadequate ventilation as well as the building materials and the finishing paints (Mokobia et al, 2003), while the minimum values 0.09 μSv/hr for indoor and outdoor measurement was observed in COEAG. It could be inferred that BIR dose equivalent in the laboratories levels indoor and outdoor as can be seen in Figure 3 follows a rise and fall pattern. This distribution pattern agrees with the observation of Mokobia and Balogun (2004) and Mokobia et al (2016). It could thus be adducing that BIR values in any region do not remain constant but oscillates between a mean value.

In Table 3 above, the mean values of the AEDE range from (0.631 – 1.016) mSv/yr for indoor and from (0.152 - 0.237) mSv/yr for the outdoor. Their respective mean values are 0.76 mSv/yr and 0.18 mSv/yr. This values are within the recommended value of 1.0 mSv/yr (ICRP,2007).

The ELCR values obtained range from 1.72 x 10^{-3} to 2.76 x 10^{-3}, with a mean of 2.06 x 10^{-3} for indoor environment and from 0.41 x 10^{-3} to 0.65 x 10^{-3}, with a mean of 0.49 x 10^{-3} for the outdoor. These values are higher than the international average value of 0.29 x 10^{-3}

(ICRP 2007). This is depicted in figure 4 and 5 respectively.

As can be seen from Figures 4 and 5, the estimated values for the AEDE are lower than the 1.0 mSv/yr recommended value of the ICRP (ICRP, 2007). On the other hand, the values estimated for the ELCR are higher than the 0.29 x 10^{-3} recommended value. The implication is the personnel in these laboratories as well as the users may develop cancer as from the age of 55 years and above. They seem therefore to be radiologically at risk.

The prediction of the semi empirical relationship between the BIR level and latitude of the location (Figure 6) reveals that the former is related to the later through the equation.
BIR= - 0.2935Lat^3 + 5.269Lat^2 - 31.53Lat + 62.995 as can be seen from the figure. This relationship is novel since there appears to be no such data in literature.

The produced BIR distribution 2-D contour map (Figure7) presents an easy to read pictorial situation of the BIR levels in each of the laboratories considered. The rise and fall of the measured BIR values are clearly captured.In conclusion the indoor BIR readings are higher than the outdoor readings. This may be as a result of accumulation of radon gas from the soil and inherent radiation from the building materials. (Mokobia et al 2016).

The radiation health parameters computed from AEDE and ELCR, indicates that AEDE values are within the recommended value of 1.0 mSv/yr. The ELCR values obtained are higher than the recommended value of 0.29 x 10^{-3}. Its implication is that the staffs and students are radiologically threatened. It is important for radiation protection agencies to swing into regulatory action and monitoring of the environment.

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